THURSDAY, MAY 30, 1878

BALFOUR ON ELASMOBRANCH FISHES

A Monograph on the Development of Elasmobranch Fishes. By F. M. Balfour, M.A., Fellow and Lecturer of Trinity College, Cambridge. (London: Macmillan and Co., 1878.)

MR. BALFOUR has finally completed and issued in the form of an octavo volume the researches on the embryology of the dog-fish and its allies, which he commenced at the now celebrated zoological station of Naples in 1874. His results have been made known from time to time during the progress of his work by a preliminary paper in the *Quarterly Journal of Microscopical Science*, October, 1874, and by a series of articles in the *Journal of Anatomy and Physiology*, the latter, indeed, being identical with the successive chapters of the present volume. Looking at the work as a whole, we may heartily congratulate not only Mr. Balfour, but English science, on the very great value of this contribution to knowledge. Mr. Balfour, before entering upon the study of the development of the shark-like fishes, had thoroughly qualified himself for the task by a careful investigation of the development of the common fowl, a subject which, although it had always been and remains the favourite, because the most handy, for the embryologist's study, yet yielded several new and interesting results to Mr. Balfour's examination. The methods which are applicable to the hardening and slicing, staining and clarifying of the embryo chick are precisely those which it is necessary to employ in the investigation of the very similar egg of the Elasmobranchs, and accordingly Mr. Balfour had well trained himself for the latter task. The prominent position in Vertebrate morphology which had been assigned to the group of Elasmobranch fishes, through the researches of Gegenbaur, rendered a minute examination of their developmental history urgent. It had become clear that we have in these fishes the nearest living representatives of the common ancestors of the great group of Gnathostomous Craniate Vertebrata, and it was to be expected that a full knowledge of their ontogeny or individual development would carry us yet further back in the line of primitive Vertebrata, and yield a mass of explanatory evidence, exhibiting the development of complex and heterogeneous structures from simpler and more homogeneous forms, likely to serve as a satisfactory starting-point for all Vertebrate morphology.

Mr. Balfour has shown in the course of his investigation of this subject not only that he is possessed of the technical skill necessary for the manipulation of such embryos, but that he is gifted with a very large measure of patience and perseverance, and has, moreover, the high critical and speculative capacities which the subject demands for its full and successful treatment.

We shall very briefly notice the successive chapters of Mr. Balfour's monograph, and point to the more important novel observations recorded, having especial regard to those which may be considered as fundamental for the morphology of Vertebrata.

Mr. Balfour begins with the ovarian ovum of the Elasmobranch, this portion of his observations having been made on the skate. He shows that the germinal vesicle atrophies before impregnation. He then proceeds to describe the process of segmentation, which, in its general features, is similar to that of the bird, the only other egg containing so large a proportion of food-material mixed up with the protoplasm of the egg-cell. In the study of the division of the first-formed cells resulting from the segregation and cleavage of the mixed materials of the egg, Mr. Balfour observed and has figured the remarkable spindle-shaped condition of the nuclei, which since has become such a prominent subject of investigation through the initiative of Auerbach, Strasburger, Bütschli, and van Beneden. Very remarkable and important nuclei are also described and figured as making their appearance in that part of the egg *not* concerned in the process of cleavage or the formation of the primitive disc of embryonic cells, and from their occurrence Mr. Balfour is led to the conclusion that the supposed distinction at this period of a purely embryonic and a purely nutritive region in the egg of the Elasmobranch, is imaginary. This is important, because similar observations have necessitated the abandonment of similar erroneous divisions of the egg of the fowl, of osseous fish, and of cephalopods. The mass of cells which form the small commencement of the embryo on the surface of the great unsegmented yelk-mass divide into an ectoderm and "lower layer-cells," and a true "segmentation cavity" comparable to that of the frog is described. The most important of Mr. Balfour's observations and suggestions which have a general bearing upon the formation of the embryonic cell-layers throughout the Animal Kingdom are those in which he points out and gives its probable significance to the fact that in the Elasmobranchs the primitive alimentary cavity (archenteron) arises as a sort of in-pushing beneath the hinder end of the embryo, a cavity being there formed between the "lower-layer-cells" and the nucleated yolk. The orifice of this cavity is spoken of by Mr. Balfour as the "anus of Rusconi," and is identified by him accordingly with the orifice so named in Amphibians. At the same time it is *not* at this orifice that the final closure of overgrowing ectoderm or epiblast takes place, that is to say, of that layer of cells which, increasing by division, spreads from the cleavage disc so as to gradually cover in the whole of the large surface of uncleft yolk. The gradually narrowing margin of these epibolic cells does not in sharks have a centre coincident with the anus of Rusconi; in fact, the blastopore, as the orifice bounded by this gradually narrowing margin is termed, lies behind the embryo altogether. Mr. Balfour suggests (and it is necessary to remember that his statements on this subject were first published three years ago) that *the primitive-streak of the bird's blastoderm is a rudimentary representative of this portion of the blastopore;* it seems necessary to say "this portion," and not the whole blastopore, as Mr. Balfour does; for tracing these various structures back with Mr. Balfour to the blastopore of the Amphioxus, we must admit that in the meroblastic ova of Sharks and Birds the blastopore has become greatly extended along the median line and has its most *anterior* portion represented in the anus of Rusconi of the Elasmobranch, a *middle* portion in the orifice of final closure of the elasmobranch's blastoderm and the primitive streak of birds and mammals, whilst a more *posteriorly* placed extension of the same

structure (blastopore) is seen in the actual orifice of final closure of the bird's blastoderm at the antembryonal pole of the yelk-sac. The continuity of the nervous and alimentary tubes, after closure of the Rusconian anus, is a striking feature which Mr. Balfour shows to be common to Elasmobranchs, Ganoids, Osseous fishes, Amphibians, Amphioxus, and Ascidians. To Kowalewsky we are indebted for the first observation of this remarkable disposition in various types of lower Vertebrata, and its full significance is not yet understood.

The next point of great importance which we find in Mr. Balfour's monograph is the derivation of the notochord from the hypoblast or archenteron, from which also the protovertebræ are developed constituting the mesoblast. That the vertebrates' body-cavity, like that of other animals, was primitively a portion of the alimentary cavity appears likely from this observation, coupled with Kowalewsky's more recent results as to the development of Amphioxus, whilst it also seems likely that the notochord made its first appearance as an organ appertaining to the alimentary tract, from which it became gradually separated in function and in structure.

The next thing which we come to is of even more special interest for the limited department of Vertebrate morphology. The *unpaired* and the *paired fins* alike make their first appearance in the Elasmobranchs as lateral ridges of epiblast, and Mr. Balfour accepts the hypothesis that the limbs are remnants of continuous lateral fins. The muscles of the limbs are shown to be derived from the "muscle-plates" of the body which develop from protovertebræ.

It is to the nervous system that some of Mr. Balfour's most original and important observations have reference. He has elsewhere conclusively shown that, contrary to Stieda's statements and in accordance with Owsjannikow's, the spinal nerves of Amphioxus have no anterior roots, that is have only dorsal roots. He now shows that the early condition of the spinal nerves of Sharks agrees with this, they having at first no anterior roots. An enigmatical commissure parallel to the medulla unites the posterior roots in the embryo. The cranial nerves—exclusive of the first and second, and the nerves to the orbital muscles which have peculiar features of their own—are shown to retain permanently the primitive condition implied in the absence of anterior roots. The vagus nerve is shown to be the result of the morphological fusion or concrescence of several segmental nerves—their separate roots (which are all dorsal ones) being "caught" (so to speak) in the sharks in process of disappearance. The identity of the nature of these roots with those of the following spinal nerves is shown by the connection with them of the enigmatical commissure above mentioned.

The segments which are represented in the Vertebrate head have been reduced and blurred by the integration of that region of the axis, but by the aid of the embryonic relations of the cranial nerves, and of a very important and remarkable series of cavities representing the body-cavity of the head (the terms are not contradictory since "head" is chiefly developed from "body") in a segmented condition, which Mr. Balfour has discovered in the Elasmobranchs, he is able to indicate distinctly at least seven post-oral segments in the cephalic axis, and he adduces cogent reasons for supposing that a larger number existed, and have been suppressed by a kind of integration.

As to the brain, Mr. Balfour gives important evidence against the fanciful interpretations of Miklucho-Maclay, whom, strangely enough, Gegenbaur has followed. What most persons call mid-brain, Miklucho-Maclay has identified with the thalamencephalon or twixt-brain (*Zwischenhirn*) of other Vertebrates, being induced by the large size of what is usually called the Elasmobranch cerebellum to consider it as the mid-brain. Mr. Balfour gives strong embryological evidence against this view.

As to the relation of nerves to the primitive germ layers, it is shown (in accordance with Hensen's observations in Mammalia) that the spinal nerves are *outgrowths* of the medulla, and Mr. Balfour, though he is unable actually to demonstrate it, yet brings a variety of evidence to show that the whole growth of the nerves is a centrifugal one, and that therefore the peripheral elements of the nervous system *may* have the same primary origin as have the central.

The important question as to how the axial medulla arose, and whether it is homogeneous with the ventral nerve-cord of Annelids and Insects is discussed in the light of the facts ascertained as to the development of the nerve-medulla in dog-fish. Mr. Balfour on the whole favours the view that the nervous system of elongated animals consisted primitively of two lateral cords, and that in Annelids and Insects these cords have met and fused *below* the alimentary tract, whilst in Vertebrates they have met and fused *above* the alimentary tract.

A curious modification of a part of the nervous system, the meaning of which is as yet entirely beyond the most hazardous speculation of either physiologist or morphologist, is shown by Mr. Balfour to present itself in the supra-renal bodies. They develop from ganglia of the sympathetic portion of the nervous system.

Lastly, we have to mention the series of results relating to the origin of the renal organs and the ducts of the generative system. These are already the most widely known and discussed, though possibly not actually the most important of Mr. Balfour's numerous discoveries. The fact that Prof. Semper, of Würzburg, occupied himself with the investigation of the renal organs of Elasmobranchs at the same time as did Mr. Balfour, and that the two investigators nearly simultaneously arrived at the same results, has given a special value to this part of the observations embodied in the present monograph. Mr. Balfour shows that the Vertebrate kidney is a condensation of tubules, of which primitively one pair existed in each segment of the body, opening into the body-cavity each by a ciliated funnel, and therefore exactly comparable to the segmental-organs or nephridia of the Annelids. Whether, as Gegenbaur holds, these organs were originally a simple pair which became segmented, that is, provided with a separate funnel in each metamere or body-segment, or whether each tubule or nephridium originally opened to the exterior, so that an unconnected series of nephridia existed on each side of the body—a pair in each segment—which subsequently became joined to one another by longitudinal common ducts—one on each side of the body—is still matter for consideration.

The adaptation of the most anterior funnel to the

purposes of an oviduct, and of a portion of the middle tubules to those of sperm-ducts is what the observations of Balfour and Semper have established—and more especially the open funnel-like character of the tubules to begin with.

Minor details and important confirmations of the more familiar facts of Vertebrate development I have not space to mention here, the whole series of embryonic phenomena is described with more or less detail by Mr. Balfour, and I have singled out the more striking facts and speculations of the monograph for brief notice.

In commenting on such a work as this, it is strongly brought to one's perception that the method of publication of the results of such laborious investigations is necessarily very imperfect—and subject to a serious deficiency in logical continuity and artistic effect. Mr. Balfour has studied the very widely-diverse phenomena of interest which the developing Elasmobranch presents from the first separation of the egg up to the nearly complete formation of all its organs. In order to state *all* the different results he has obtained, he is obliged, as is usual in embryological monographs, to give them in historical sequence. To the experienced student of embryology this method of statement and the presentation of drawings copied from actual sections and specimens is sufficient. It would be impossible to publish observations within a reasonable period of the date of investigation by pursuing any other method of statement. And yet the monographical and historical method, together with the objective "nature-true" drawings of sections is one which prevents an author from fully exhibiting the import of his observations, and from duly imparting to the reader in a clear and simple form what is, after all, the thing which the reader desires to know, namely, what is the net result of such observations in relation to the great questions of morphology. The fact is, there is no such thing as a science of embryology; it is not even a definite branch of a science. The development of organic form is a necessary part of the science of Organic Morphology, and the results of the study of development can be given with full clearness and in an intelligible manner only when formulated as parts of the general doctrine of the science under which they fall. The conclusion from this is, that the great value of Mr. Balfour's work will not be fully appreciated or rendered clear to the majority of zoological students until they are re-stated, not from the monographical standpoint; but from the more general point of view of Animal Morphology. This more systematic exposition of his Elasmobranch studies and of other like researches in combination with a general survey of the morphology of all groups of the Animal Kingdom as revealed by their developmental histories, we may expect before long to receive from Mr. Balfour himself in the form of a continuation of his well-known Elements of Embryology.

E. RAY LANKESTER

OUR BOOK SHELF

Gold. By Edwin W. Streeter, F.R.G.S. Fifth Thousand. (London: Chapman and Hall.)

THE lettering on the cover of the book, as given above will hardly prepare the reader for the statement on the title-page, that the work is a translation and abridgment of Herr von Studnitz' "Die gesetzliche Regelung des Feingehaltes von Gold und Silber-Waaren," by Mrs. Brewer, with notes and additions by Mr. Streeter.

The work itself contains information which it is useful to possess. It embodies brief abstracts of the law of various countries concerning the standard of gold and silver wares, and discusses the question whether the manufacture of articles in the precious metals should be subject to legal control. Mr. Streeter's notes occupy 10 out of the 150 pages. He states that the system of "Hall-marking" was "instituted on the supposition that the assay and test of precious metals was a matter too recondite to render a power of adequate discrimination for so valuable a transfer of property a thing reasonably to be expected of the public generally."

This is a very obscure way of saying that, as the value of gold and silver wares could not be recognised by inspection, it was advisable that all articles should be stamped by authority. The necessity for such control has long been felt, and it was well justified in 1677 by the author of the "New Touchstone for Gold and Silver Wares," who says: "The truth is, the gain by adulterating gold and silver works is so sweet and enticing that what excuse will not these adulterators find that they may have their unlawful liberty."

In London the control has been wisely vested in the Goldsmiths' Company since the fourteenth century, and in the country there are several assay offices which were reported on by a Select Committee of the House of Commons in 1856. Mr. Streeter urges that gold of one standard only—18 carat—should be used, or that if other alloys are employed the tradesman should "mark them with his own name, state the value of the composite matter, and trust to his genius for the sale." Trusting to genius for the sale of articles is all very well, but the practice of a person stamping the wares he sells with his own mark surely affords no protection against the fraudulent tradesman as the marks are not likely to outlive the age in which they are impressed, and would be as readily counterfeited as those of a responsible authority. It should also be added that the initial or distinctive mark of the maker of an article of gold or silver is already included in the Hall mark.

LETTERS TO THE EDITOR

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Alternate and Stereoscopic Vision

WITH reference to Mr. Galton's observation in his instructive paper in NATURE, vol. xviii. p. 98, that "sometimes the image seen by the left eye prevails over that seen by the right, and *vice versâ*," I may mention that, as I had noticed some years ago, this may be best observed without a stereoscope. If on looking at any object a few feet distant, a nearer object be placed about midway between the first and the eyes, there will of course be two images seen of the near, when the eyes converge on the distant; one of these images seen, say by the right eye, overlaps the distant object as seen by the left eye, and if the two objects be about equally illuminated (or the near one rather the brighter), the overlapping image will alternately solidify and disappear, according to the alternate waxing and waning of sensibility in the eyes. This alternation may be made at will, by desiring to see the near or the distant object; the fluctuations take place about every ten seconds normally, but the changes may be willed (though not so completely) as often as every second.

If the observer can see stereoscopically without an instrument, *i.e.*, can dissociate the usually coincident motions of focussing and convergence, this alternate action of the eyes is seen very